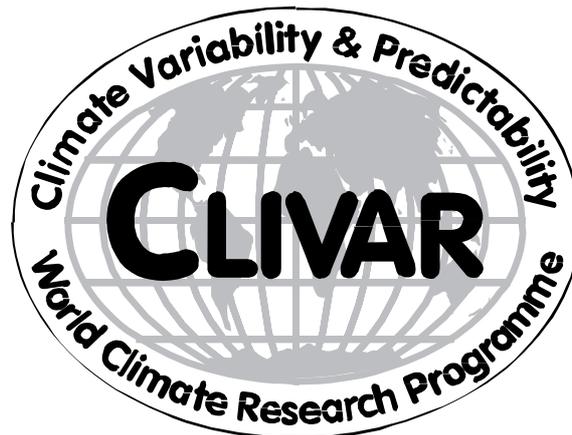


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## WORLD CLIMATE RESEARCH PROGRAMME



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## Introduction

Ruth Curry, co-chair of the CLIVAR Atlantic Implementation Panel (AIP), welcomed all present panel members and guests (see appendix A) to Woods Hole where the 9<sup>th</sup> session of AIP took place.

Wilco Hazeleger, AIP co-chair, reviewed the agenda of the meeting (see appendix B) and stated the main goals:

- Review the implementation of the Atlantic climate research and observations
- Discuss the legacy and future of CLIVAR and AIP: from sunset to transition
  - Immediate (< 2 yrs, activities)
  - Mid-term (- 2012, activities, legacy and strategy)
  - Long term – COPES (post 2012, strategy)
- Plan on-going and new activities:
  - Toulouse TACE/TAV/PIRATA meeting
  - Decadal prediction meeting
  - Contribution to GSOP, OceanObs 09 etc.
  - South Atlantic implementation
- Coordinate and discuss with US Atlantic Meridional Overturning Circulation (AMOC) group

CLIVAR is a networking project, that aims to advise, initiate and stimulate activities towards better collaboration and coordination among nations. CLIVAR Atlantic overviews, implements and advises on the Atlantic observing system through workshops, assessments, endorsements, science white books etc....

CLIVAR contributes to the implementation of COPES (Coordinated Observations and Prediction of the Earth System), the WCRP strategic framework for 2005-2015. All aspects of CLIVAR work should be measured against the COPES crosscut themes:

- Seasonal Prediction
- Monsoons
- Decadal Prediction
- Anthropogenic climate change
- Atmospheric chemistry and climate
- Climate Extremes
- IPY
- Sea Level rise

## The Tropical Atlantic Climate Experiment (TACE)

The main focus of TACE is to improve predictions and understanding of the eastern tropical Atlantic climate and the representation in models of key dynamical processes underlying its behavior. TACE was envisioned as a program spanning a period of approximately 6 years (2006-2011). The results of TACE are expected to contribute to the final design of a sustained observing system for the tropical Atlantic.

P. Brandt updated the AIP members on the progress of TACE observations. During the last years the establishment of the TACE observing system made substantial progress. While the PIRATA program represents the backbone of the observational network, several observational programs - partly initiated with the help of TACE – are currently active in the central and eastern tropical Atlantic (visit <http://tace.ifm-geomar.de/>).

Particularly in the eastern tropical Atlantic, which was, during recent years, characterized by exceptional low data coverage, a large amount of data became available. With the last (out of six) research cruises of the French EGEE (Etude de la circulation océanique et de sa variabilité dans le golfe de Guinée) program (as part of the African Monsoon Multidisciplinary Analysis (AMMA) program, in cooperation with PIRATA (see next section) & TACE) into the Gulf of Guinea in June and September 2007, a major effort ended during which measurements of radiative fluxes and atmospheric parameters for the calculation of turbulent fluxes were systematically made along with profiles of temperature, salinity and currents in the mixed layer. In combination with an extensive

upper ocean microstructure program (M. Dengler, IFM-GEOMAR), the acquired data set represents a unique database for the analysis of the evolution of the oceanic heat budget during the onset and mature phase of the equatorial cold tongue.

Additional observations of the upper ocean current system have been carried out in the framework of PIRATA as well as by US and German research programs. The US Equatorial Undercurrent (EUC) program is aimed at observing the EUC in the eastern Atlantic through new moored current meter (ADCP) observations at 10°W and 0°E, for a three-year period from September 2007 to September 2010. The German EUC program includes a mooring array along the 23°W meridian consisting of 5 moorings between 2°N and 2°S that will be maintained until boreal summer 2011. The next cruises to service the moorings are scheduled within the US EUC program in spring 2009 (with an additional R/V Antea cruise in September 2008) and within the German EUC program in November 2009.

The objectives of both projects are to provide a thorough description of the mean state and variability of the EUC in the central and eastern Atlantic including its seasonal intensity and eastward penetration of into the Gulf of Guinea. Equatorial wave dynamics are the particular focus of these programs, including study of the effect of Tropical Instability Waves (TIWs) and Kelvin waves on sea surface temperature (SST) variability in the eastern tropical Atlantic and associated climate variability in the tropical Atlantic region.

As part of the French PIRATA observation system, and as contribution to TACE & AMMA, a subsurface ADCP mooring has been deployed on the equator at 10°W; this mooring will be replaced in September 2008 during the French PIRATA FR18 cruise.

NOAA's Global Drifter Program is working to maintain a global array of 1250 drifters at 5x5 degree resolution, including the Tropical Atlantic. Many deployments are conducted from AX8, a Volunteer Observation Ship line between Cape Town, South Africa and the US east coast. In the central and southern Tropical Atlantic, drifters move west from that line, strongly affecting the subsequent data distribution. Other opportunities, such as the US Navy's African Partnership Station, are used to deploy drifters east of AX8. A number of international partners also deploy drifters throughout the region.

Argo floats in the central and eastern Tropical Atlantic were deployed mainly in the framework of US, French and German Argo programs. While the data coverage in the equatorial Atlantic is largely improved compared to previous years, in the Tropical Southeast Atlantic there are still large gaps.

A major German research program (SFB 754) focuses on the climate-biogeochemistry interactions in the tropical ocean with particular emphasis on the oxygen minimum zone in the Tropical North Atlantic. This program includes observations from subsurface hydrographic (oxygen) and current meter moorings at 5N and 8N along the 23W meridian, a tracer release experiment at 300 m depth (tracer injection was in April 2008), a glider repeat section along 23W and extensive biogeochemical and physical shipboard observations. The first 4-year phase of the program started in 2008. This program will strongly enhance the physical and biogeochemical database in the tropical North Atlantic between the equator and Cape Verde Islands.

All measure shortwave radiation, currents at 10m, air temperature, sea temperature and salinity at multiple depths, wind speed and direction, rain, and humidity. The full-flux site at 11.5N, 23W also includes longwave and barometric pressure. These moorings are serviced approximately once per year, with complementary hydrographic observations, a dense hydrographic line along 23W to 1500dbar, and opportunistic oceanic (drifter, floats, XBTs, thermosalinograph, ADCP) and atmospheric (sondes, ozonesondes and direct turbulent fluxes) measurements.

Ping Chang gave an overview of the progress made by the TACE Modeling Working Group (WG). The main goal of the project is to determine the ocean processes that are misrepresented in General Circulation Models (GCMs) and contribute to the modeled Atlantic Intertropical

Convergence Zone (ITCZ) bias. The WG focused on the processes involving the Barrier Layer (BL- the layer between the halocline and the thermocline) physics. This is poorly represented in Ocean GCMs (OGCMs) because of:

- Observational uncertainties for precipitation
- Absence of low frequency/high amplitude rainfall events (e.g. afternoon thunderstorms, hurricanes)
- Misinterpretation of river outflows because of numerical constraints

Observed seasonal variation of BL thickness in the tropical oceans shows that the northwestern tropical Atlantic warm pool area is one the most frequent BL occurrence areas in the tropical oceans. The BL most frequently forms from the boreal late fall to late winter. The depth can reach up to 50m. However, coupled GCM experiments with improved river outflow and superimposed massive precipitation events did not show any significant impact on the ITCZ position.

The WG is currently investigating two processes:

1) Magnitude and importance of Parametric Subharmonic Instability (PSI). PSI in the North Atlantic strengthens the Deep Western Boundary Current (DWBC) which pushes the Gulf Stream south  
2) Effect of Meridional Overturning Circulation (MOC) changes on tropical Atlantic variability. A substantially weakened MOC causes the increasing of SST in equatorial Atlantic, a decrease in the African Monsoon strength and the reduction of Atlantic El Niño.

Some preliminary studies show that enhancing signal-to-noise in coupled models by suppressing atmospheric internal variability leads to improved SST forecasts in the south tropical Atlantic.

### **The Pilot Research moored Array in Tropical Atlantic (PIRATA)**

During 2007-2008, the PIRATA Project presented an above average data return, with all its present 17 systems (10 backbone moorings since 1998; 3 SW extension moorings since 2005; 4 NE moorings since 2007). Four of the moorings (6S-10W; 0N-23W; 12N-23W, and 15N-38W) became Full Flux capable reference sites from 2007, with the added sensors for Outward Longwave Radiation (OLR) and Sea Level Pressure (SLP) on each buoy. Current meters were also installed on these ATLAS systems. In addition, the 0N 23W upward-beaming ADCP continues to collect data, which is retrieved annually by the French cruises.

PIRATA Northeast Extension (PNE moorings at 4N-11.5N, 20.5N-23W and at 20N-38W) measure shortwave radiation, currents at 10m, air temperature, sea temperature and salinity at multiple depths, wind speed and direction, rain, and humidity. The full-flux site at 11.5N-23W also includes longwave and barometric pressure. These moorings are serviced approximately once per year, with complementary hydrographic observations, a dense hydrographic line along 23W to 1500dbar, and opportunistic oceanic (drifter, floats, XBTs, thermosalinograph, ADCP) and atmospheric (sondes, ozone sondes and direct turbulent fluxes) measurements.

During the PNE 2007 cruise, AOML personnel conducted hydrographic casts along 23W, at the PNE site 20N-38W and at the Brazilian PIRATA backbone mooring site 11.5N-38W, and deployed drifters, floats and XBTs. PMEL personnel supervised the recovery and deployment of the PNE moorings. Collaborators with NOAA/ESRL, NOAA/NESDIS, Howard University and the University of Miami collected a broad suite of observations including atmospheric dust, humidity, and ozone profiles, direct air-sea flux measurements, and sea surface skin temperatures.

During the 10 year period: 1998-2007 the overall data return of the array was 81%, which places the PIRATA array close to the data return average of the Tropical Atmosphere-Ocean (TAO) array over the tropical Pacific Ocean. Also, the number of data files delivered by the PIRATA web site grew from 132 in 1999 to 61,494 files in 2007, totaling 170K files during the existence of the PIRATA array.

Presently, pCO<sub>2</sub> and O<sub>2</sub> sensors are collecting data at the PIRATA sites 8N-38W (since March 2008) and 6S-10W (since June 2006), as part research on Atlantic Ocean CO<sub>2</sub> cycle by a French PI (Nathalie Lefevre, IRD/LOCEAN) (see: <http://www.lodyc.jussieu.fr/CO2tropiques/>).

In the eastern Atlantic, the Sao Tome meteorological (installed 2003) and tide gauge (installed 1980) stations receive routine maintenance by the French. The Met station has been transmitting its data via GTS since October 2006. The station also measures and transmits SLP, Sea Surface Salinity (SSS) and SST.

In the western Atlantic, the Saint Peter and Saint Paul Archipelago received the visit of a technician from INPE, which will install INPE's automatic met station and tide gauge station during the next cruise to the archipelago during October 2008. Fernando de Noronha Island automatic met station has been operational since its installation in 2004 with routine maintenance done by the Laboratory of Meteorology of Pernambuco – LAMEPE.

A paper was published in BAMS in August 2008 with the title: "The PIRATA Program: History, Accomplishments, and Future Directions", providing the cover story for the volume.

At last meeting of the PIRATA SSG it was decided to substitute the name "Pilot" with "Prediction" in the PIRATA acronym. The next PIRATA meeting will be held in Toulouse, France, back-to-back with a Tropical Atlantic variability (TAV) meeting in February 2009.

### **Working Group for Seasonal-to-Interannual Prediction (WGSIP)**

WGSIP aims focus on a programme of numerical experimentation for seasonal-to-interannual variability and predictability, paying special attention to assessing and improving predictions. Further research aims are to develop appropriate data assimilation, model initialization and forecasting procedures for seasonal-to-interannual predictions, and to consider such factors as observing system evaluation, use of ensemble and probabilistic methods and statistical and empirical enhancements, and measures of forecast skill. The WGSIP has, in the past, set up a number of model intercomparisons including the Seasonal prediction Model Intercomparison Project (SIMP). These coordinated numerical experiments clearly demonstrate that successful seasonal prediction is a multi-model and multi-institutional problem.

WGSIP organized the first WCRP (World Climate Research Programme) Seasonal Prediction Workshop, which was held in Barcelona (Spain) in June 2007. Since then, WGSIP has been involved in is coordinating two major modelling and prediction efforts that are of interest to the Atlantic Implementation Panel (AIP). The first activity is the Climate-System Historical Forecast Project (CHFP), which was developed as a major Pan-WCRP effort. The CHFP is managed and coordinated by WGSIP, but includes design input and collaboration from all of the relevant WCRP core projects (i.e., CLIVAR, GEWEX, SPARC, CliC). The second major project is being developed in coordination with the WCRP/CLIVAR Working Group on Coupled Modelling (WGCM) and will be part of the experimental design for modelling inputs to the 5<sup>th</sup> Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5). This modelling project emphasizes decadal climate prediction for the first time as well as long term (century timescale) climate simulations.

The CHFP is contributing to the WCRP aim of determining the predictability of the complete climate system on time scales of weeks to decades. By complete climate system, we mean contributions from the atmosphere, oceans, land surface, cryosphere and atmospheric composition in producing regional and seasonal climate anomalies. The problem of prediction and predictability of seasonal climate variability is necessarily multi-model and multi-institutional. The CHFP is designed to provide:

- a baseline assessment of our seasonal prediction capabilities using the best available models of the climate system and data for initialisation.
- a framework for assessing current and planned observing systems, and a test bed for integrating process studies and field campaigns into model improvements
- an experimental framework for focused research on how various components of the climate system interact and affect one another
- a test bed for evaluating IPCC class models in seasonal prediction mode

The core experiment is an 'Interactive Atmosphere-Ocean-Land-Ice Prediction Experiment' emphasizing the use of comprehensive coupled general circulation models which include realistic interactions among the component models. The initialization strategy is to use the best available observations of all the components of the climate system.

A question for AIP is how to address the tropical biases in the Atlantic and improve models. It was suggested that the CHFP provides a good way to build the interactions between AIP and WGSIP to improve predictions in the Tropical Atlantic. The chair of AIP, Wilco Hazeleger, suggested the TACE/AMMA-Ocean workshop (Toulouse February 2009, <http://www.legos.obs-mip.fr/en/observations/pirata/meeting/2009/index>) as the first opportunity to discuss Data-Model intercomparison.

**ACTION ITEM 1.** Contact Bernard Bourles and suggest including Laurent Terray, Peter Brandt and Ping Chang in the scientific organizing committee of the TACE/AMMA-ocean meeting in Toulouse (Feb. 2009). Also suggest that Laurent Terray and Peter Brandt take the lead in defining the science programme. See action 2 (L. Terray, P. Brandt and Ping Chang)

Wilco Hazeleger suggested WGSIP and WGOMD provide short-term (covering TACE timescales) and long-term (AMOC) model runs before the February workshop and present a plan for model-data intercomparison, which addresses errors in the models.

**ACTION ITEM 2.** Work with WGSIP and WGOMD to provide seasonal forecast runs and CORE (Coordinated Ocean Reference Experiment) ocean-only runs for model-data intercomparison in the tropical Atlantic region. Make a plan for intercomparison to attribute errors in the models. Strawman plan and first results to be presented in Toulouse (2009) (Ben Kirtman, Ping Chang, Yochanan Kushnir and Laurent Terray)

In order to promote model-data intercomparison activities, the following actions were proposed:

**ACTION ITEM 3.** Make sure that the TACE hydrographic data are available to the community. Check best way/data centre to handle the data (Peter Brandt)

**ACTION ITEM 4.** Design a CLIVAR webpage with links to CORE runs, reanalysis products (Mercator, ECCO, etc...), observations and seasonal prediction runs (R. Boscolo)

It was suggested Ping Chang be nominated as co-chair of the TACE modelling WG to help with fostering the link with WGSIP

**ACTION ITEM 5** Suggest Ping Change as co-chair of the TACE modelling WG and include Yochanan Kushnir in the group (Wilco Hazeleger and Yochanan Kushnir)

Y. Kushnir reminded the meeting of the importance of the climate processes associated with the Atlantic Marine ITCZ (AMI). The gaps in our understanding of what controls the location and intensity of the Inter-Tropical Convergence Zone (ITCZ) are reflected in large biases in ITCZ rainfall simulated by the majority of atmospheric GCMs forced with observed SST. These biases are exacerbated in coupled models, resulting in erroneous tropical SST distributions as well. The consequences of these discrepancies affect our ability to describe, understand, and predict regional climate variability. The problem is particularly frustrating in the Atlantic, where model biases are very large in a region where the variability of the marine ITCZ is closely linked with significant rainfall variation in the densely populated coastal regions.

**ACTION ITEM 6.** Explore the possibility of a 'revival' of the AMI plan (Yochanan Kushnir)

## **US AMOC Progress**

In January 2007, the US Joint Subcommittee on Ocean Science and Technology (JSOST)

identified the “improved understanding of the mechanisms behind fluctuations of the Atlantic Meridional Overturning Circulation (AMOC), which will lead to new capabilities for monitoring and making predictions of the AMOC changes” as a near-term priority in the Ocean Research Priorities Plan (ORPP). In response to this near-term priority, a panel of scientists developed an implementation plan

([http://www.usclivar.org/science\\_status/AMOC/AMOC\\_Strategy\\_Document.pdf](http://www.usclivar.org/science_status/AMOC/AMOC_Strategy_Document.pdf)), released in October of 2007. The five-year implementation plan laid the groundwork for an inter-agency program that will develop the initial components of an AMOC monitoring system and AMOC prediction capability. In response to this implementation plan, the supporting agencies (NASA, NOAA and NSF) created a US AMOC Science Team in March 2008

(<http://www.AtlanticMOC.org/index.php>). This Science Team, which is comprised of all funded investigators under this program, bears the responsibility of accomplishing the program objectives with guidance and oversight from the supporting agencies. The program objectives are the following:

1. Design and implementation of an AMOC Monitoring system
2. Assessment of AMOC’s role in global climate
3. AMOC predictability

The administration requested \$40M for the ORPP plan for FY08, however the Omnibus Funding Bill passed by Congress provided only \$11.25M. Agency contributions from related programs nominally brought this up to \$17M of which up to \$7.2M was designated for AMOC activities. Of that, \$4M was expected from NOAA, but budget constraints have prevented NOAA from funding AMOC activities in FY08. The result is that a maximum of only \$3.2M is available for AMOC in FY08. Several legacy and a few recently-funded projects are being molded into an interagency program focused on the Atlantic Meridional Overturning Circulation in an effort to address the 4th near-term priority of the administration’s Ocean Research Priorities Plan.

This comprises a modest start on only the most urgent activities. Funding limitations during FY08 curtailed development plans and only a few new projects were funded in the highest priority areas. The bulk of the program consists of projects continuing from previous years.

The US AMOC discussion-session organized as part of the AIP meeting was meant to provide a list of current issues that the US AMOC Science Team is addressing and that might benefit from an international coordination with other AMOC initiatives (UK-RAPID, EU-THOR, EU-Combine, etc.). Discussion took place around the following:

- What are gaps in our understanding of the AMOC and its variability (discussion leader: W. Johns)*
- Design of an AMOC Observing System (discussion leader: M. Baringer)*
- Measurement Systems to address the gaps (discussion leader: J. Baehr)*

The US AMOC Science Team will organize their first annual meeting in May 2009 (<http://www.AtlanticMOC.org/AMOC2009.php>). The AIP suggested that this meeting should be open to international participation.

**ACTION ITEM 7.** Suggest international participants for the AMOC workshop in Annapolis (April 2009). (Susan Lozier, Ruth Curry and Jerry Miller)

### **Thermohaline Overturning at Risk? (THOR): a European Union (EU) funded project**

THOR is an EU large-scale integrating project with more than 20 European institutions involved. THOR will establish an operational system to monitor and forecast the development of the North Atlantic thermohaline circulation (THC) on decadal time scales and assess its stability and the risk of a breakdown in a changing climate. Together with pre-existing data sets, ongoing observations within the project will allow precise quantitative monitoring of the Atlantic THC and its sources. This will, for the first time, allow an assessment of the strength of the Atlantic THC and its sources in a consistent manner and will provide early identification of any systematic changes in the THC that might occur. Analysis of palaeo observations covering the last millennium and millennium time

scale experiments with coupled climate models will be carried out to identify the relevant key processes and feedback mechanisms between ocean, atmosphere, and cryosphere. In THOR, the combined effect of various global warming scenarios and melting of the Greenland ice sheet will also be thoroughly assessed in a coupled climate model. Through these studies and through the assimilation of systematic oceanic observations at key locations into ocean circulation models, THOR will forecast the development of the Atlantic THC and its variability until 2025, using global coupled ocean-atmosphere models. THOR will also assess induced climate implications of changes in the THC and the probability of extreme climate events with special emphasis on the European/North Atlantic region. THOR builds upon techniques, methods and models developed during several projects funded within 5<sup>th</sup> EU Framework Programme (FP5) and FP6 as well as many nationally funded projects. The project will contribute to Global Monitoring for Environment and Security (GMES, now called Copernicus, [www.ec.europa.eu/copernicus/services/climate.htm](http://www.ec.europa.eu/copernicus/services/climate.htm)), to Global Observing Systems such as to the Global Ocean Observing system (GOOS), and to the International Polar Year (IPY).

The level of funding received from EU is about 10M Euros for 4 years and this will be matched with approximately the same amount from institutional funding. The Project will start in December 2008, Prof. Dr. Detlef Quadfasel is the coordinator.

**ACTION ITEM 8.** Find out opportunities for marine observations in the European GMES program (R. Boscolo)

### South Atlantic Activities

Albero Piola updated the panel on the observational efforts being carried out in the subtropical and subpolar South Atlantic after the SAMOC Workshop held in Buenos Aires in May 2007 (<http://eprints.soton.ac.uk/50121/>).

As reported at the last AIP meeting in March 2007, the South Atlantic meridional heat flux estimates differ widely. Around 30°S, the estimates range between < 0.2 PW (Trenberth & Solomon, 1994) to > 0.9 PW (ERA15, ECMWF). Thus, one of the overreaching goals of the workshop was to reduce the uncertainty of estimates of the basin-wide ocean heat fluxes at mid latitudes. Improved S. Atlantic heat fluxes (HFs) combined with HF estimates in the subtropical North Atlantic, will help reduce large uncertainties in oceanic heat divergence and therefore ocean-atmosphere HF. The issue is particularly relevant to recent warming of the subpolar North Atlantic. Current meridional HF ( $Q_y$ ) estimates are based on the methodology of Baringer and Garzoli (2007) employing high resolution XBT surveys being obtained quarterly between South America and South Africa. Twenty two sections have been collected since mid 2002 leading to values of  $0.53 \pm 0.12$  PW.

There are several shortcomings related to  $Q_y$  estimates based on XBT observations only, but the adjustment of the mass transport depends heavily on the western and eastern boundary. For this reason, PIES arrays (see below) had been proposed for both, the eastern and western boundaries, as a way to minimize these uncertainties. Experience in the N. Atlantic suggests similar uncertainties may arise from the mid-ocean ridge. The western boundary array (SAMOC-W, see figure 1) was originally planned for deployment in October 2008, but it has been postponed until January 2009. The array includes three inverted echosounders equipped with pressure sensors (PIES) and one equipped with both a pressure gauge and a single depth acoustic current meter (CPIES). The array will be deployed for a period of four years.

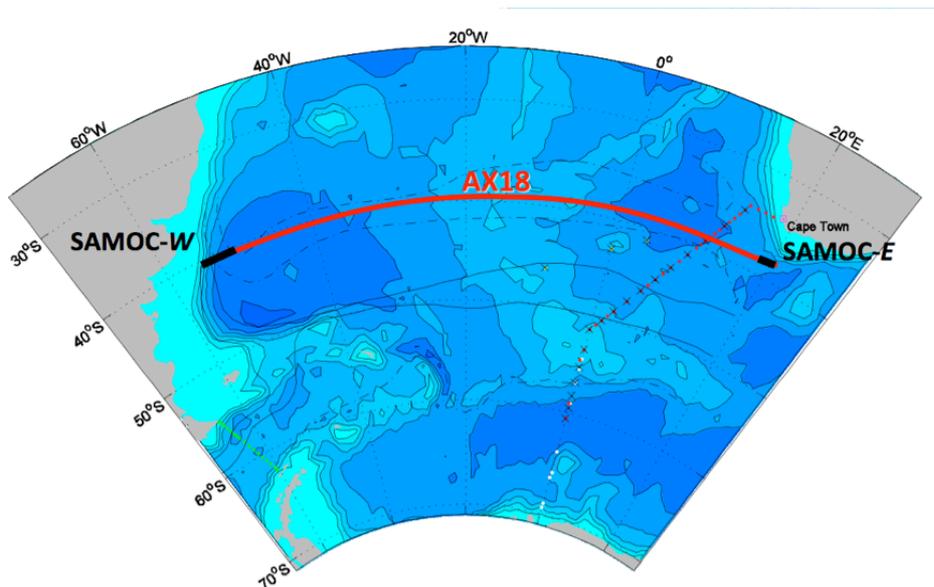


Figure 1

A similar program has been started at the eastern boundary by the group lead by S. Speich (IFREMER, FR), who deployed a pair of CPIES along 35°S in February 2008 (SAMOC-E, see Figure 1). The tentative plan is for annual (or possibly semi-annual) cruises to acoustically download data from the PIES/CPIES and to produce a daily time series of DWBC transport. CTD profiles will be collected at the four instrument sites during each cruise, and opportunities are available to augment these observations with other work by the contributing scientists. The boundary current transport time series described above will help reduce transport error estimates based on XBT observations.

There are other initiatives in the western subtropical South Atlantic. In April 2009 the UK (NOC) will occupy a transatlantic section at 23°S on R/V James Cook. The new plan moves north of from 30°S to avoid the topography associated with the Rio Grande Rise, and moved north rather than south to avoid the variability associated with the Brazil/Malvinas Confluence. In addition, one full depth transect (V) will be occupied in the Vema Channel and three full depth CTD transects will be collected on the continental slope between Santos and Cabo Frio. This section will also be reoccupied by the US Carbon project, date to be confirmed.

BRAVO (Brazil Current Velocity Observations) is a project lead by E. McDonagh (NOC, UK) that aims at measuring the Brazil Current transport and test the hypothesis that its transport and variability is set by the wind-driven transport in the South Atlantic. The project is under evaluation at the UK's funding agency. The project proposes to measure the Brazil Current transport, determine the phase and magnitude of its seasonal cycle and extend the transport time series using altimeter data to provide a climate index for the South Atlantic circulation. For this purpose, a current meter array consisting of eleven moorings will be deployed. The array will be located on altimeter track 50. Brazilian investigators (E. Campos, USP and P. Nobre, INPE) are planning to complement the above observations on the continental shelf. Funding for a shelf extension has not yet been secured.

Just north of this same region the Movar project led by Mauricio Mata (FURG, BR) has occupied a repeat XBT line, approximately bimonthly across the Brazil Current (BC), since August 2004. The project aims at monitoring the regional variability of the heat transport associated with the upper layer of the BC near 21S. The section takes advantage of a logistic cruise between Rio de Janeiro and Trinidad Is. Upper-layer BC transport estimates based on this XBT line suggest substantial seasonal variability having maxima in Austral summer and being very weak in winter. The South Atlantic Climate Change (SACC) consortium is an international initiative focused on the continental shelf and its interaction with the western boundary currents. It is financed primarily by the IAI and aims at understanding the physical mechanisms leading to regions of high biological

activity. It has coordinated relatively large scale multidisciplinary surveys, such as the Plata experiment and is currently coordinating the deployment of several mooring sites including oceanographic and meteorological observations. SACC research is very relevant to IGBP IMBER.

An array of seventeen C-PIES has been deployed at the Drake Passage (T. Chereskin, K. Donohue and R. Watts), the array will remain in the water for 4 years; a service cruise is planned for November 2008. The array is aimed at measuring the flow between the South Pacific and South Atlantic Oceans. These observations add to the routine occupation of UK line SR1b and several other XBT and underway measurements by several nations.

In late March-early April 2009 R/V Polarstern will occupy two sections across the Drake Passage to service the LOCEAN current meter array (C. Provost). CTD and underway measurements will be collected during the cruise.

AWI-Bremerhaven (PI O. Boebel/A. Macrander) deployed 6 PIES at Jason-1 crossover points on the GoodHope section of Track #133 (and 3 additional PIES somewhat to the north for GRACE comparisons). The recovery is planned in 2011-12.

A high density XBT line along the GoodHope line (to the south of Africa) started in February 2004 with two to three transects carried out each year. These transects are carried out in a collaboration between the University of Cape Town, NOAA/AOML, University of Brest, and the Shirshov Institute of Oceanology. Ten transects have been completed. The objective of this line is to investigate the Indo-Atlantic water exchanges and their impact on the global thermohaline circulation, to study the variability of the frontal regions and their transports between South Africa and Antarctica, and to support other environmental and meteorological observations carried out during each transect. A group led by R. Matano (OSU, US) and E. Palma (UNS, AR) has implemented a set of high-resolution numerical simulations of the western South Atlantic with emphasis on the shelf circulation and shelf-open ocean exchanges. The simulations are based on the Princeton Ocean Model and are forced with global tides, satellite and reanalysis derived monthly mean winds, western boundary currents and continental discharge from major rivers. The above studies are complemented by simplified, process-oriented simulations aimed at determining the role of the different forcings in establishing the 3-D circulation and the dynamics of shelfbreak formation. Additional basin scale modelling efforts are aimed at investigating the low-frequency variability of the South Atlantic and the South Indian Ocean circulation and interocean exchanges (R. Matano).

Overall there seems to be a good level of activities in the western part of the South Atlantic however very little is going on the eastern part. Given the situation, it is too early to initiate analysis of data basin-wide with aim of building a synthesis picture. However AIP members suggested starting model-data intercomparison

**ACTION ITEM 9.** Contact Anne-Marie Treguier to do help with synthesis work in the S. Atlantic (Alberto Piola)

They also suggested performing OSSEs to guide scientists in deploying instruments in S. Atlantic in order to add elements to the observing system

**ACTION ITEM 10.** Contact George Halliwell and Johanna Baehr to perform OSSE experiments in South Atlantic (Bill Johns and Alberto Piola)

### **SouthWestern Atlantic climate Variability Experiment (WAVEs)**

WAVEs is a proposed field experiment and ocean-atmos-biosphere coupled modeling research program to study ocean-atmosphere-land coupled phenomena leading to South Western tropical Atlantic-South American climate variability and change. The basic research foci are:

- South Atlantic Convergence Zone (SACZ)-related seasonal rainfall predictability
- SST variability and change; ocean heat fluxes

From the point of view of seasonal climate predictions, the SACZ phenomena constitutes a challenging science target from the perspective of organizing a comprehensive oceanic and atmospheric research program to study this novel branch of climate research, namely the predictability of coupled ocean-atmosphere modes of variability. The following processes constitute elements with which a more comprehensive picture of the SACZ dynamics and its interactions with SST and continental rainfall can be built:

- SST-Solar Radiation-Rainfall feedback processes
- Barrier layers due to SACZ rainfall over the ocean and river discharges
- Amazon soil moisture-rainfall memory: ITCZ-SACZ-Low Level Jet interactions?
- Remote influences from the eastern equatorial Atlantic
- Teleconnections from the South Pacific Convergence Zone (SPCZ)

In addition to the atmospheric processes that contribute to modulate SST variability over the SW tropical Atlantic, there are also oceanic phenomena that imprint SST variability locally or remotely. In addition, on longer time scales, the working of the meridional overturning cell – MOC and the subtropics-tropics cell – STC modulates the meridional heat transport across the equatorial Atlantic. Such meridional heat transport is a key element of global climate stability and change.

The WAVES concept was proposed at last VAMOS meeting and although the idea was well accepted, no collaborative initiatives were proposed. Paulo Nobre recognized that the lack of progress with WAVES is due to the lack of collaboration with South American colleagues.

**ACTION ITEM 11.** Form a working group with South American scientists to push forward the WAVES concept; write science and implementation plans (Paulo Nobre)

**ACTION ITEM 12.** Suggest a special focus on S. Atlantic observations and synthesis in both Annapolis and at the TACE workshop (Wilco Hazeleger and Alberto Piola)

### **African Activities in the South Atlantic sector**

At the moment, the PIRATA SE extension still requires funding for a second ATLAS mooring. The Benguela Current Large Marine Ecosystem (BCLME) programme funded an initial mooring with ship time provided by France (IRD). At the last PIRATA meeting, discussions were held with Mike McPhaden about the possibility of NOAA providing a second mooring in return for local ship-time to assist with ATLAS mooring deployment in the Indian Ocean. A 3-year pilot project that includes buying another mooring has been integrated in within several multi-institutional national proposals like the African Centre for Climate and Earth System Science (ACCESS).

ACCESS, headed by George Philander, is preparing a bid for large scale funding to the South African government Dept of Science and Technology to help support climate modelling, operational oceanography and other earth system science components with the Atlantic aspects playing a prominent role. Of particular interest to AIP are the aspects dealing with the science underpinning the prediction of the Benguela Nino and low oxygen events in the South East Atlantic.

A new CO<sub>2</sub> observation programme for the South East Atlantic and Southern Ocean sector south of South Africa has been started by CSIR South Africa in collaboration with the University of Cape Town. The SOPOP (Southern Ocean Carbon Observation Project) is a long term initiative to observe changes in the ocean - atmosphere fluxes of CO<sub>2</sub> in the Southern Ocean to the South of Africa. It will comprise a gradually increasing set of underway observations starting with ocean/atmospheric pCO<sub>2</sub>, & surface layer TA, TCO<sub>2</sub>, Chla, O<sub>2</sub>, T, S expanding in the coming year to include a number of other variables in the upper mixed layer and lower atmosphere. It takes advantage of both the geographic location of South Africa in a relatively under sampled zone of the Southern Ocean as well as the three annual trips that the SANAP ship SA Agulhas undertakes between Cape Town and the Antarctic bases. These cruises offer an excellent and up to now a relatively under-utilised opportunity to sample this sector over three seasons.

In February-March 2008, the RV Marion Dufresne completed an extensive survey which included CTD, XBT, biogeochemistry and radiosonde observations, to mention but a few. This was the fourth CTD and twelfth XBT section completed in the GoodHope program's short history, which commenced in 2004. Additionally, the deployment of Argo floats (approx. 16 deployed during the most recent GoodHope occupation) has helped to fill the Southern Ocean gap of floats for this region of the South Atlantic. Proxy methods applied to the CTD and XBT data can be used to infer subsurface hydrographic information from 16 years of satellite altimeter data. This includes being able to infer baroclinic transports of the Antarctic Circumpolar Current (ACC) from altimeter SSH data alone (Swart et al. 2008, JGR). More recently, applying altimeter SSH data to the Gravest Empirical Mode in order to gain a better understanding of the subsurface thermohaline structure has proven to be a very successful method in such a data sparse region of the world's ocean. Finally Chris Reason suggested contacting Dr Chris Bartholomae of the National Marine Information and Research Centre in Namibia to help with the SAMOC line.

**ACTION ITEM 13.** Contact Chris Bartholomae (Namibia Marine Research Centre, cbartholomae@mfmr.gov.na) to help with the planning of SAMOC line (Alberto Piola and Chris Reason)

Ben Kirtman stated that the South Atlantic is a good place to explore coupled model biases. It is therefore important to encourage more process studies in this sector and to engage model people in designing them. Ben Kirtman also informed that he is proposing a US CLIVAR Working Group on Tropical Biases.

**ACTION ITEM 14.** Make sure that the Atlantic is well represented in the US CLIVAR Tropical Biases working group (Ben Kirtman and Wilco Hazeleger)

### **Decadal Prediction**

Decadal climate prediction is a focus of the WCRP strategic framework as part of WCRP's "seamless prediction" strategy. Decadal climate prediction is a "meeting ground" for the weather and climate modelling communities because it must take into account both accurate initial conditions and future concentrations of greenhouse gases (GHGs). Furthermore decadal climate prediction poses challenging scientific questions, such as: does the impact of GHG forcing on decadal timescales depend on initial conditions? Do estimates of initial-condition predictability depend on GHG forcing?

The theme has been discussed at the previous Atlantic Panel meeting, partly because of the potential role of the Atlantic meridional overturning circulation and related requirements for the observing system. A number of projects, with Atlantic Panel member involvement, will address decadal predictions (e.g. US AMOC, EU ENSEMBLES, EU THOR, EU COMBINE).

The last decade has seen substantial progress in the development of coupled ocean-atmosphere models, in global data assimilation systems for the ocean and the atmosphere, and in ocean observing systems. With these data assimilation systems, retrospective global analyses of the ocean and atmosphere state have been made covering the past 40 years. In addition, impact and application models, e.g., for health, agronomy and hydrological applications, have been developed and coupled to climate models.

Building on these developments WCRP has initiated a cross-cutting activity to advance the science of decadal climate prediction. An early effort has focused on internationally-coordinated multi-model experimentation to gauge the overall level of predictability arising from having both different initial conditions and different greenhouse gas forcings. A detailed proposal is being developed on numerical experimentation to assess the expected skill of decadal predictions. It is anticipated that the programme of experimentation initiated by this programme will contribute to the IPCC Fifth Assessment Report.

The WCRP proposal aims to

- Provide model integrations to allow estimation of the evolution of expected climate for the period 2005-2035, relative to the climate of recent decades.
- Encourage use of higher-resolution climate models, with the hope of better resolving synoptic processes associated with extremes, and assessing the benefits of higher resolution in general.

With above activities coming up, Wilco Hazeleger suggested the panel organize a workshop on this subject, following upon a successful workshop in Reading 2004. Since most groups will start running their coupled models for the Coupled Model Intercomparison Project CMIP5 mid-late 2009/early 2010, a broad workshop on the results would probably be too early. It was therefore proposed that a smaller workshop (~50 attendants) be held on the subject of “Coupled Initialization for Decadal Predictions”, to be held in 2009 possibly in Amsterdam.

**ACTION ITEM 15.** Organize a workshop on initialization methods for decadal prediction (Wilco Hazeleger)

### Inputs to OceanObs09

The OceanObs’09 conference will take place on 21-25 September 2009 in Venice Italy (<http://www.oceanobs09.net/index.php>). The meeting will celebrate progress in implementing the existing initial ocean observing system, realizing societal benefits from it and highlighting its potential. It also aims to develop a consensus plan for sustaining and evolving systematic and routine global ocean observations over the next 10 years in support of societal benefits. OceanObs’09 is planned around and is firmly based on community contributions and community consensus provided in three levels as input to the conference. Those are:

- Invited Plenary talks, accompanied by Plenary Papers, drawing from community input
- Community White Papers proposed by the groups as input to the plenary talks, and
- Volunteer Additional Contributions

The invited plenary talks, decided by the conference organizers, will have one lead author with other contributing authors and will be built up from community white paper input.

- *Day 1* will focus on celebrating a decade of progress and preparing for the future.
- *Day 2*, scientific results and potential based on global observations these, will summarize progress in the last decade; identify the big remaining research questions and challenges; and identify current and needed assets in the observing system that will allow progress, making reference to the Community White Papers on observing networks.
- *Day 3*, services, forecasts, and impacts/management, will provide particular examples of the benefits of ocean information, outlining the scientific and technological underpinning for generating services for society and identifying the current and needed elements of an observing system in order to make progress, making reference the appropriate Community White Papers.
- *Day 4*, frontiers of global ocean observations, will be visionary papers based on upcoming in situ or satellite technology and projects, making reference the submissions from the Community White Papers.
- *Day 5*, the benefits of global and regional ocean observations, will describe the plan for the coming decade for a sustained, interdisciplinary observing system and showcase examples of significant benefits, confronting in particular the frameworks in place and needed to make progress.

The community papers will be solicited as group contributions with one identified corresponding author. They need to be forward-looking, stating new opportunities for a particular element of the sustained observing system (not a process study), a CEOS satellite virtual constellation, or stating the requirements for a user need. They will refresh existing plans in the light of new information and technology, or describe contributions to the sustained global ocean observing system from new communities with a plan for a globally-deployed network or infrastructure or service. They need to clearly identify the community contribution to one or more topics addressed by the Plenary

Papers, labeled as either a 'core' or 'relevant' contribution to each of these topics.

**ACTION ITEM 16.** Coordinate the submission of a community white paper on AMOC for OceanObs'09 (Ruth Curry)

**ACTION ITEM 17.** Contribute to the community white paper on decadal prediction for OceanObs'09 (Wilco Hazeleger and Magdalena Balmaseda)

### **Clivar Mode water Dynamics Experiment (CLIMODE)**

CLIMODE is a major, ongoing process study (2005-2009, <http://www.climode.org/>) of the formation, subduction and dispersal of 'Eighteen Degree Water' (EDW), the subtropical mode water of the North Atlantic. EDW is a canonical example of subtropical mode waters, all of which are found in regions of significant air-sea exchange. EDW is created in the winter just south of the Gulf Stream, by convection in the presence of strong shear, with competing effects of vertical/lateral mixing and advection/stirring colluding to set its properties. The scientific goals of CLIMODE are focused in 4 areas:

- Air Sea Interaction
- Eddies and Mixing
- Subduction & Circulation
- Modeling

The program is a mix of *in situ* and satellite-based observations, and modeling which will, over a 5 year period beginning October 2004, lead to improved parameterization of air-sea fluxes in a high exchange region of the oceans, and improved ocean physics in climate models, capturing the eddy-mixed layer interactions in a region with both strong flows within the ocean and atmosphere and large wintertime exchange between the ocean and atmosphere. CLIMODE is working with the US CLIVAR "Critical Process Team" ([CPT-emilie](#)) to develop better climate models.

The Field Phase is completed, future work comprises:

- Introductory article (recently accepted in BAMS)
- Second PI Workshop in Woods Hole in Aug. 2008 – report progress, encourage group efforts, submission of data sets to CLIMODE server
- CLIMODE results at a session at Fall 2008 AGU
- CLIMODE results to be presented at WBCWG workshop following Winter 2009 AMS
- Scientific papers being written & under review
- CLIMODE Analysis/Synthesis Proposal(s) planned for Feb. 2009 submission to NSF

### **CLIVAR and WCRP future directions: an Atlantic perspective**

The discussion was organized around the following questions:

1. What should the observing system look like?
2. What will the community work on?
3. What are the big science questions with regard to predictions?

Ruth Curry and Wilco Hazeleger asked the participants to provide short written answers and Roberta Boscolo collected the inputs (see Appendix C).

Jim Hurrell was invited to introduce the WCRP implementation plan. Since he couldn't attend the AIP meeting in person, Ruth Curry set up a telecon with him. Jim Hurrell introduced the activity to define the evolution of WCRP in the near- and long-term. Such activity initiated from a WCRP document which sets out a number of detailed questions to which CLIVAR (and the other WCRP core projects) is asked to respond. The key issue is to identify the priority science questions to be addressed over the coming years and beyond. The CLIVAR SSG co-chairs are requesting the panels and working groups to address the following three questions:

1. What are the imperatives for the panel over the coming years to 2013 and, perhaps, continuing over the next decade? Imperatives are those activities and/or plans that "must" be continued and/or implemented because they are of the highest scientific importance (e.g., they address the most important science issues) with a high likelihood of success.
2. What are the frontiers the panel envisions for the next decade and beyond? Frontiers are new research areas judged to be of great importance, worthy of seeking funding and developing research efforts/programs around, etc.
3. What key developments to enabling infrastructure do you see as necessary to deliver to the above.

This bottom-up exercise is meant to represent the expertise, interests and perspectives of the panel.

**ACTION ITEM 18.** Provide the CLIVAR SSG with the AIP view on key scientific objectives on short term (< 2012), midterm (2013-2020) and long term (> 2020) (Wilco Hazeleger, Ruth Curry and Roberta Boscolo)

## **CLIVAR Global Synthesis and Observations Panel (GSOP) activities in the Atlantic sector (Detlef Stammer)**

### ***Velocity Workshop***

GSOP has promoted a "Workshop on Ocean Velocity Measurements and their Applications" which was held at SIO, La Jolla, USA, on 5-7 December 2007. The report can be found at [http://eprints.soton.ac.uk/50803/01/129\\_GSOP\\_Workshop.pdf](http://eprints.soton.ac.uk/50803/01/129_GSOP_Workshop.pdf). The group has made several recommendations which are being evaluated by GSOP.

One issue raised was that the actual requirement for current measurements made by surface drifters is one measurement per month, per 5° box, with an accuracy of 2 cm/s. This is an issue that should be addressed by the Atlantic Panel to see if these requirements are still valid for the Atlantic sector.

The workshop participants also addressed the theme of western boundary currents and equatorial current systems as a gap in the velocity observing system. It is unclear whether the oceanographic community knows precisely what should be observed, or how those observations should be made. Analyses from process studies in these regions (e.g. the Kuroshio Extension System Study (KESS), CLIMODE,...), however, may provide some guidance.

**ACTION 19.** Provide GSOP with the AIP needs on ocean velocity measurements (Peter Brandt and Bill Johns)

### ***Repeat Hydrography***

GSOP is a co-sponsor (together with the International Ocean Carbon Coordination Project (IOCCP) and the IGBP SOLAS-IMBER Carbon Coordination Group) of the Global Ocean Shipbased Hydrographic Investigations Panel (GO\_SHIP). The panel brings together interests from physical hydrography, carbon, biogeochemistry, Argo, OceanSITES, and other users and collectors of hydrographic data.

The first panel meeting was held in Victoria B.C., Canada on 1-2 November 2007 to develop guidelines and advice for the development of a globally coordinated network of sustained ship-based hydrographic sections that will become an integral component of the ocean observing system. One of the points identified by the group was that the Atlantic sections need to be redefined. There is also the issue of who is going to occupy them and that of a synthesis.

**ACTION 20.** Suggest to ICPO to find out how best to inform the community on the planned Hydrography sections (R. Boscolo and Stuart Cunningham)

**ACTION 21.** Contact the US repeat hydrography committee to find out the planned Hydrography sections and publicize those (Ruth Curry)

### ***Ocean Synthesis and Reanalysis***

GSOP is organising a 3rd Ocean Synthesis Evaluation Workshop, to be held at JAMSTEC Office in Tokyo, on 6-8 October 2008.

As done previously, one of the topics that will be compared among different products is the MOC behaviour, in addition to heat content, freshwater and sea level. This will be done globally but also for the Atlantic. Many of the GSOP synthesis activities are addressing specifically the Atlantic sector. The AIP has proposed a matrix for evaluation of ocean synthesis products in the Atlantic sector (see Appendix D)

**ACTION 22.** Send the list of Atlantic research questions for analysing the synthesis products to Detlef Stammer to present it at the next GSOP Ocean Synthesis Evaluation Workshop in Tokyo (October 2008) (Ruth Curry)

**ACTION 23.** Identify papers that use synthesis products (Wilco Hazeleger)

### ***Decadal Predictions***

GSOP is playing a leading role in the question of providing initial conditions for decadal predictions. Much needs to be learned about the proper use of ocean syntheses for the initialization of coupled climate models. First tests performed have been promising. Upcoming efforts in this respect include the EU THOR programme. As already noted, for input to IPCC AR5 a dedicated effort is being defined through WGCM to produce initialized decadal predictions as a component of CMIP5. GSOP will provide all existing ocean syntheses fields for potential use.

### ***Climate Datasets***

GSOP has started an effort to produce a climate-quality data set. Emphasis is first of all on an expansion of the data sets available on the WOCE data CD to present day. In parallel efforts have started to clean up the historic in situ ocean data as well, which will also be made available.

## **WGOMD activities**

### ***Coordinated Ocean-ice Reference Experiments (COREs)***

WGOMD has completed CORE I, a comparison of seven global ocean-ice models run for 500 years using the same atmospheric forcing. The experimental design and simulation results are documented in Griffies et al. (2008, Ocean Modelling). An electronic version is available on the WGOMD website (<http://www.clivar.org/organization/wgomd/wgomd.php>).

CORE-II focuses on interannually varying forcing based on reanalysis and observational products. The CORE-II effort will provide a common framework for running ocean-ice models for hindcast purposes. WGOMD is in the process of determining the details of the experimental protocol, and then documenting a suite of model simulations with this protocol. Notably, CORE-II efforts will feed into CLIVAR panel activities aiming to use models to identify mechanistic descriptions of observed variability and change. Details of the CORE experiments are available on the CORE website (<http://www.clivar.org/organization/wgomd/core/core.php>). WGOMD welcomes any comments and suggestions from the AIP members.

### ***Repository for Evaluating Ocean Simulations (REOS)***

This is a CLIVAR web site that is coordinated by WGOMD. The motivation for this web page stems from the growing needs of the modelling community to provide benchmark, thorough evaluations of their simulations, and to make use of newer observational datasets having been generated the past decade.

Essentially, this is a website that will facilitate access to observational datasets, develop a discussion on ocean metrics and ocean model evaluation, and provide tools and references for the

community. Ideally what will come out of this is a discussion within the ocean modeling community that will lead to a recommendation for a standardized baseline approach for evaluating ocean climate studies. An ocean modeler who wants to compare results to observations should also be able to use this site to determine what data he/she should get hold of and from where. Efforts at developing a prototype REOS web site are underway, which the AIP is invited to take a look at ([www.clivar.org/organization/wgomd/reos/reos.php](http://www.clivar.org/organization/wgomd/reos/reos.php)). Input is solicited in terms of suggestions and ideas on how to improve the site, as well as specific recommendations from the AIP for the evaluation of simulations of the Atlantic basin (see Metrics).

### **Recommendations for CMIP5**

A document is being prepared by WGOMD that will outline recommendations on the variables to be archived from the ocean models for CMIP5. This will address 1) space and time sampling (e.g., remapping to sphere or not; remapping to depth/pressure or not), and 2) a list of variables with rationale for adding more and modifying some. In particular, the CMIP3 repository has almost no variables saved that relate to ocean subgrid scale parameterizations. These recommendations will lead to a far richer CMIP5 repository for use by ocean scientists who study fundamental processes.

### **WGOMD Workshop on Ocean Mesoscale Eddies - Met Office Hadley Centre, UK, 27-29 April 2009**

The intense level of research activities related to ocean mesoscale eddies prompts the WGOMD to hold a scientific workshop with the following main goals:

- To educate the research community regarding the importance of mesoscale eddies in the World Ocean, and correspondingly for establishing features of the ocean climate system;
- To identify best practices for parameterizing ocean mesoscale eddies in coarse resolution climate models, and to discuss various research avenues for improved parameterizations;
- To evaluate the ability of state-of-the-science numerical models to accurately represent the ocean mesoscale in eddying simulations.

The three-day workshop will consist of six speakers per day. Each speaker will present views on the state-of-the science in ocean mesoscale eddies as seen through observations, models, and theory. Each day will also have time to view posters contributed by interested workshop participants.

See the attached flyer for a complete list of speakers and visit the workshop webpage for more information and access to a detailed workshop proposal:  
[http://www.metoffice.gov.uk/conference/mesoscale\\_workshop/](http://www.metoffice.gov.uk/conference/mesoscale_workshop/)

### **Report on joint SOLAS/IMBER carbon data products**

The EU project CARBOOCEAN has together with the Joint SOLAS/IMBER Carbon Group (co-chairs: A. Körtzinger/IFM-GEOMAR, Kiel, Germany; T. Johannessen, Univ. Bergen, Norway) developed the two major and internationally significant data synthesis products CARINA and SOCAT:

**CARINA – Carbon in the North Atlantic:** One of the major objectives of the European-funded CARBOOCEAN IP is the quantification of decadal-to-centennial Atlantic and Southern Ocean carbon inventory changes. Operationally this implies the need to quantify “the Atlantic and Southern Ocean carbon sinks, and their decadal change, through highest accuracy measurement of the changing inventories of inorganic carbon and carbon-related tracers. Atlantic and Southern Ocean data would then be integrated into a coherent global data base”. The science delivery associated with this objective is “a large scale assessment of the ocean carbon storage”. A final workshop took place in Paris in July 2008 where a set of 2<sup>nd</sup> level (i.e. consistency control) adjustments of the Atlantic carbon and ancillary data (carbon system parameters, salinity, dissolved oxygen, major nutrients, CFCs) was agreed upon. During the last years, the CARINA data base has grown significantly with the help of the CARBOOCEAN IP as well as the

international research programs IMBER and SOLAS. An initial Atlantic Ocean Carbon Synthesis Meeting was held in Laugarvatn, Iceland, in 2006. Since then further meetings have been held in Kiel/Germany in March 2007 and in Delmenhorst/Germany in November 2007. During this time, the 1<sup>st</sup> level quality control of the data has been continuing and software for thorough data evaluation was developed.

During the final Paris meeting the three regional working groups (Nordic Seas, North Atlantic, Southern Ocean) spent most of the time exploring the crossover analyses and results of the inversion-based error estimates on a cruise-by-cruise basis. Adjustments were assigned to a number of cruises following detailed inspection of the data where specified offset thresholds were exceeded and other evidence supported the presence of a systematic offset.

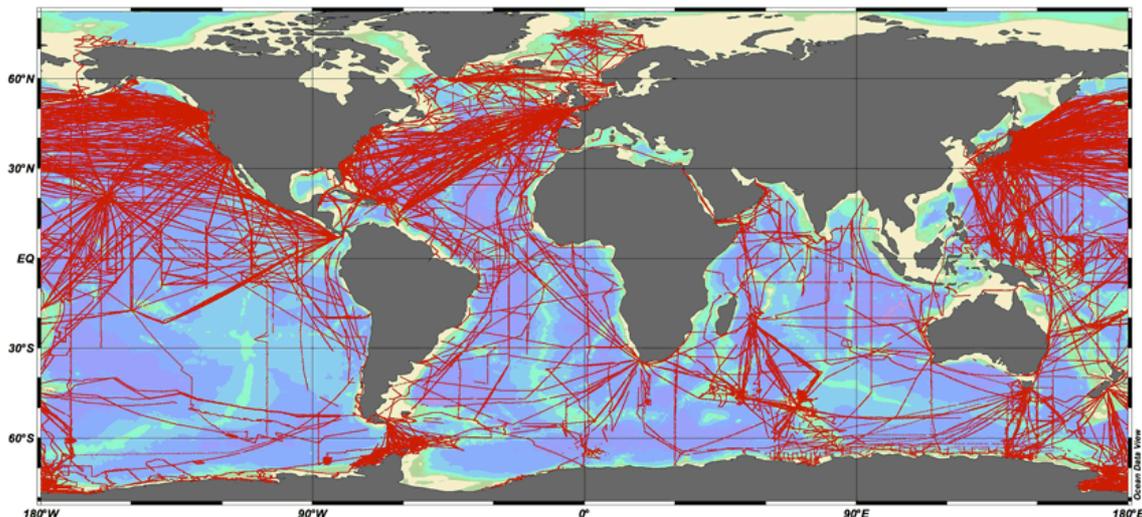
At the present time the adjustment table is being finalized and will be made publicly available soon. An overview article on this emerging consistent database will be prepared for publication in *Global Biogeochemical Cycles* (lead author Bob Key, Princeton University). For the publication of the database itself in the *Earth System Science Data (ESSD)*, published by Copernicus publications, has been proposed. This is an international, interdisciplinary journal for the publication of articles on original research data (sets), furthering the reuse of high (reference) quality data of benefit to Earth System Sciences.

A follow-up workshop on “Decadal Variations of the Ocean’s Interior Carbon Cycle: Synthesis and Vulnerabilities” (organizers: N. Gruber, ETH Zürich/Switzerland; A. Körtzinger, IFM-GEOMAR, Kiel, Germany; S. Riser, Univ. of Washington, Seattle, USA) will be carried out in Ascona, Switzerland on July 13-17, 2009.

**SOCAT – Surface Ocean CO<sub>2</sub> Atlas**: An important goal for SOLAS, IMBER, and CARBOOCEAN is the establishment of surface ocean and atmosphere carbon observing systems for constraining the net annual air-sea CO<sub>2</sub> flux to at least 0.2 Pg C yr<sup>-1</sup> per basin. Detecting interannual and longer term variation in CO<sub>2</sub> air-sea fluxes and identifying the natural or anthropogenic origin of such variation is also central in the Joint SOLAS-IMBER Carbon Group (sic!). The Surface Ocean CO<sub>2</sub> Atlas (SOCAT) project emerged during the 2007 Surface Ocean CO<sub>2</sub> Variability and Vulnerability (SOCOVV) workshop in Paris ([http://ioc3.unesco.org/ioccp/pCO2\\_workshop/SOCOVVhome.html](http://ioc3.unesco.org/ioccp/pCO2_workshop/SOCOVVhome.html)) as a way of assessing whether we are approaching these goals. Two types of SOCAT products will be made available with regular updates:

- a 2<sup>nd</sup> level quality controlled, global surface ocean *f*CO<sub>2</sub> (fugacity of CO<sub>2</sub>) data set following agreed procedures and regional review,
- a gridded SOCAT product of monthly surface water *f*CO<sub>2</sub> means on a 1° x 1° grid with no temporal or spatial interpolation.

The decision was made to use the well-documented, common format data set of Benjamin Pfeil (CARBOOCEAN data manager) and Are Olsen (Bjerknes Centre, Bergen, Norway) as the basis for SOCAT data set (see Figure 2) which already contains over four million data points from the period 1968-2007 and is rapidly growing. Regional groups for the oceans and coastal seas, as well as an overview global group were established during SOCOVV to ensure that the quality control procedures are tailored to regional issues, but still comparable on a global scale.



**Figure 2** - Spatial overview of surface water CO<sub>2</sub> data in SOCAT version 1.1.

The IOCCP and the Joint SOLAS-IMBER Carbon Group (sic!) sponsored a small, technical kickoff meeting on SOCAT for the global and regional group leaders, data managers and LAS (Live Access Server) specialists at IOC/UNESCO (Paris) on 16 and 17 June 2008. A report of this SOCAT-2 meeting will be soon available at <http://www.ioccp.org/>.

Over the next few months the regional groups will become firmly established, will identify and submit missing data sets and will explore which 2<sup>nd</sup> level quality control checks may be performed in each region (deadline 1 September 2008). After 15 September 2008, the regional groups are asked to carry out 2<sup>nd</sup> level quality control on the SOCAT data and address key process-related scientific questions requiring large-scale joint synthesis efforts, while aiming for scientific presentations at ICDC-8 (International Carbon Dioxide Conference) in September 2009 and a first public release of the two SOCAT products by late 2009. Marine CO<sub>2</sub> scientists and modelers keen in participating in the above activities are encouraged to contact regional or global group leaders.

## Membership and Next meeting

Wilco Hazeleger asked to step down as AIP co-chair and to be rotated off. His current new position as Head of the Climate Unit at KNMI prevents him to continue to dedicate time and effort for AIP. The present members and co-chair thanked him for his dedication in the last 4 years and recognized the value of his leadership and vision

The other members whose terms had finished are: R. Sutton, B. Johns, N. Koc, A. Piola and L. Terray. It was agreed to extend Terray's term.

**ACTION 24.** Find a replacement for Wilco Hazeleger, Bill Johns, Nalan Koc, Alberto Piola, Rowan Sutton; Extend the term of Laurent Terray for two more years (Ruth Curry and R. Boscolo)

It was proposed to held next meeting in Brazil attached to a tropical Atlantic workshop and/or PIRATA meeting

**ACTION 25.** Organize next panel meeting in South America possibly attached to PIRATA meeting and tropical workshop (R. Boscolo)

## APPENDIX A: List of Attendees

### 1.1 Panel Members

Curry Ruth	WHOI, USA	rcurry@whoi.edu
Hazeleger Wilco	KNMI, de Bilt NL	hazelege@knmi.nl
Brandt Peter	IfM, Kiel GER	pbrandt@ifm-geomar.de
Cunningham Stuart	NOCS, UK	scu@noc.soton.ac.uk
Johns Bill	RSMAS, Miami, USA	wjohns@rsmas.miami.edu
Koc Nalan	NPI, Tromso NO	Nalan.Koc@npolar.no
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Stammer Detlef	IfM, Hamburg, GER	<a href="mailto:detlef.stammer@zmaw.de">detlef.stammer@zmaw.de</a>
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### 1.2 Guests and Observers

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### 1.3 ICPO

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### 1.4 Panel Members not present

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## Appendix B. Agenda

### Day 1 – 18<sup>th</sup> September 2008

8:00 meet in the lobby of Nautilus Inn for a lift to meeting venue/ van leaves 8:15

8:30-9:00 arrival, coffee etc

9:00-9:45 Welcome, logistics, goals, agenda, review action items, CLIVAR/WCRP updates (W. Hazeleger, R. Curry and R. Boscolo)

9:45 -12:30 Tropical Atlantic Session.

- Introduction by W. Hazeleger
- TACE Overview (P. Brandt and P. Chang, 30 min.)
- PIRATA Review (P. Nobre, 20 min.)
- Discussion on agenda for the Toulouse workshop and where the science of tropical Atlantic variability should go (leading discussion P. Brandt, P. Nobre, B. Kirtman)

12:30-13:30 Lunch (offered by WHOI)

Afternoon: AMOC Session

The planned focus of the joint AIP/US AMOC afternoon workshop is on how to meet AMOC goals that are shared by the international community. The specific focus will be on the design and implementation of further components of an AMOC monitoring system.

13:30-13:45 Introduction and brief summary of US AMOC effort (*Susan Lozier*)

13:45-14:30 Discussion of the current gaps in our understanding of the AMOC and its variability (*Bill Johns*)

14:30-15:00: Discussion of the subset of these gaps that can be met with further measurements (*Molly Baringer*)

15:00-15:30 Coffee Break

15:30-16:15 Discussion of the measurement system that most efficiently closes these gaps (*Johnna Baehr*)

16:15-17:00 Discussion of how the U.S. can most effectively contribute to this measurement system in partnership with international collaborators (*Susan Lozier*)

17:00-17:30 Summary and recommendations (*Susan Lozier*)

### Day 2 – 19<sup>th</sup> September 2008

8:15 Van leaves Nautilus Inn

8:30-9:00 arrival, coffee etc

9:00-10:30 South Atlantic session.

- South Atlantic observations (A. Piola, 20 min)
- WAVES (P. Nobre, 20 min)
- Eastern South Atlantic initiatives (C. Reason, 20 min)
- Discussion on coordination and future activities (leading: A. Piola, P. Nobre and C. Reason)

10:30-11:00 coffee break

11:00-12:00 WCRP activities (Decadal Predictions).

- Review protocol (W. Hazeleger)
- Discussion on main priorities and follow up of 'Reading' workshop on decadal predictability

12:00-12:30 OceanObs09 (D. Stammer)

12:30 – 13:30 Lunch (offered by WHOI)

13:30-14:30 AIP legacy and WCRP future directions: telecon with Jim Hurrell

- What has CLIVAR AIP accomplished?
- Key science issues to address over the incoming years to 2013?
- Elements to be taken forward beyond next decade?
- New science to be addressed beyond 2013?

14:30-15:00 CLIMODE (T. Joyce)

15:00-15:30 Coffee Break

15:30-16:30 Links with other programs. Discussion on the written report:

- GSOP – activities using ocean synthesis products (D. Stammer)
- WGOMD (S. Griffies doc)
- IMBER/SOLAS & CLIMECO (W. Hazeleger)
- CliC Arctic Sea Ice group (R. Curry)
- Aquarius/SMOS cal/val initiatives (R. Curry, S. Cunningham, D. Stammer)

16:30-17:30. Panel issues:

- New membership and co-chair
- future workshops
- next meeting

18:30 Panel dinner chez Ruth Curry

## **Appendix C . CLIVAR Future: Atlantic Vision**

### **What should the observing system look like?**

- 1) MOC Observing system in place
- 2) Subpolar/subtropical Gyres monitoring
- 4) Deep Argo network (+ O<sub>2</sub> + nutrients + ADCP)
- 5) WBCs + choke points monitoring
- 6) Autonomous Instruments
- 7) All surface parameters from Satellite
- 8) Glider network
- 9) Expand array of moored buoys (full flux measuring)
- 10) Island-coastal network of tide gauges
- 11) Tropical array for air-sea fluxes
- 13) Process studies (enhance measurements) to address model improvement
- 14) All data in real time centrally data collection

### **What will the community work on?**

- 1) Regional Impacts (+ basin impacts)
- 2) Probabilistic Climate Forecasts
- 3) AMOC stability and Predictability: spectra of MOC on longer timescales, explain subseasonal + decadal variability of MOC
- 4) Resolving systematic errors of coupled o-a models (tropical equatorial atlantic)
- 5) End-to-end systems: prediction up to decision making
- 6) Climate impacts on ecosystems
- 7) small-scale processes to be parametrized in global models
- 8) Improving data assimilation for ocean reanalysis
- 9) Analysis of reanalysis models and climate prediction models
- 10) Integration IPCC/GWEX

### **What are the big science questions with regard to predictions?**

- 1) Predictability/predictions at regional and scales
  - Regional skill
  - Downscaling
- 2) Addressing model biases (Tropics)
  - Model errors
- 3) How to better integrate process studies results into climate models?
- 4) In what way does model realism limit decadal prediction?
- 5) How to design in an optimal way ensemble prediction systems?
- 6) Model evaluation: metrics based on processes and detection and attribution techniques
- 7) AMO/AMV Predictability and mechanisms
- 8) Ice Discharge and sea level rise
- 9) Where are the thresholds in the climate system?
- 10) Stability, characteristics of the earth system
- 11) MOC and gyre variability
- 12) What are the timescales of climate variability on which the ocean matters?
- 13) Coupled o-a modes of variability over the South Atlantic (SACZ-SST interactions)

**APPENDIX D: Scientific Evaluation of Ocean Synthesis Products in the Atlantic Sector**

Metric	AIP members willing to lead analysis in collaboration with GSOP	
MOC transport at 24.5N and other latitudes	Stuart Cunningham will coordinate with members of RAPID and THOR communities	
Heat / FW transports across 24.5N RAPID/MOCHA	Bill Johns	
Baroclinic transport index (Bermuda – LabSea)	Ruth Curry	
Meridional T gradient (Benguela region)	Chris Reason	
ATL3 tropical SST index Equatorial Cold Tongue	Peter Brandt and the TACE group	
24S AMOC experimental design	Ruth Curry, Johanna Baehr	
Heat/ FW content	Laurent Terray	
Re-emergence of winter mixed layer T	Yochanan Kushnir	
E-P in the South Atlantic SSS Atlantic	Paulo Nobre Arnold Gordon	
Volumetric FW storage changes	Ruth Curry	

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